APPENDIX B

DETERMINATION OF BASIC STRUCTURAL HAZARD SCORES AND MODIFIERS

This Appendix presents the derivation of the Basic Structural Hazard score and discusses modifications to account for building specific problems and to extend this score to areas outside of California. Sample calculations of probabilities of damage and resulting Basic Structural Hazard scores are included for several building types. A summary of Basic Structural Hazard scores for all structural types and for all regions is found in Table B1.

B.1 Determination of Structural Score S

The Basic Structural Hazard (BSH) is defined for a type or class of building as the negative of the logarithm (base 10) of the probability of damage (D) exceeding 60 percent of building value for a specified NEHRP Effective Peak Acceleration (EPA) loading (reflecting seismic hazard) as:

$$BSH = -\log_{10}[Pr(D \geq 60\%)] \qquad (B1a)$$

The BSH is a generic score for a type or class of building, and is modified for a specific building by Performance Modification Factors (PMFs) specific to that building, to arrive at a Structural Score, S. That is,

$$BSH \pm PMF = S \qquad (B1b)$$

where the

$$\text{Structural Score } S = \log_{10}[Pr\,(D \geq 60\%)] \qquad (B1c)$$

is the measure of the probability or likelihood of damage being greater than 60 percent of building value for the *specific* building.

Sixty percent damage was selected as the generally accepted threshold of major damage, the point at about which many structures are demolished rather than repaired (i.e., structures damaged to 60 percent of their value are often a "total loss"), and the approximate lower bound at which there begins to be a significant potential for building collapse (and hence a significant life safety threat). Value is used as defined in ATC-13 (ATC, 1985), which may be taken to mean replacement value for the building.

The determination of the probability of damage exceeding 60 percent for a class of buildings or structures for a given ground motion defined in terms of Modified Mercalli Intensity (MMI), Peak Ground Acceleration (PGA) or Effective Peak Ground Acceleration is a difficult task for which insufficient data or methods presently exist. In order to fill this gap, earthquake engineering expert opinion was elicited in a structured manner in the ATC-13 project, as to the likelihood of various levels of damage given a specified level of ground motion (ATC, 1985).

The Basic Structural Hazard scores herein were developed from earthquake damage related information, using damage factors (DF) from ATC-13 (ATC, 1985), wherein damage factor is defined as the ratio of dollar loss to replacement value. It is assumed in ATC-13 that, depending on the building class, both modern code and older non-code buildings may be included, and that the damage data are applicable to buildings throughout the state of California. Inasmuch as ATC-13 was intended for large scale economic studies and not for studies of individual structures, damage factors apply to "average" buildings in each class. ATC-13 damage factors were chosen as the

Table B1: Basic Structural Hazard Scores for all Building Classes and NEHRP Areas

	Building Identifier	Seismic Area (NEHRP MAP AREAS) low (1,2)	moderate (3,4)	high (5,6,7)
W	WOOD FRAME	8.5	6.0	4.5
S1	STEEL MRF	3.5	4.0	4.5
S2	BRACED STEEL FRAME	2.5	3.0	3.0
S3	LIGHT METAL	6.5	6.0	5.5
S4	STEEL FRAME W/CONCRETE SW	4.5	4.0	3.5
C1	RC MRF	4.0	3.0	2.0
C2	RCSW NO MRF	4.0	3.5	3.0
C3/S5	URM INFILL	3.0	2.0	1.5
PC1	TILT-UP	3.5	3.5	2.0
PC2	PC FRAME	2.5	2.0	1.5
RM	REINFORCED MASONRY	4.0	3.5	3.0
URM	UNREINFORCED MASONRY	2.5	2.0	1.0

basis for the handbook scores because, at the present time, this is the most complete and systematically compiled source of earthquake damage related information available. Appendix G of ATC-13 contains summaries of experts' opinions of DFs for 78 facility classes (designed in California) due to 6 different levels of input motion. Each ATC-13 expert was asked to provide a low, best and high estimate of the damage factor at Modified Mercalli Intensities VI through XII. The low and high estimates were defined to be the 90% probability bounds of the damage factor distribution. The best estimate was defined for the experts as the DF most likely to be observed for a given MMI and facility class (Appendix E and equation 7.10, ATC-13). This relationship is illustrated in Figure B1.

To incorporate the inherent variability in structural response due to earthquake input and variations in building design and construction, the DF is treated as a random variable—that is, it is recognized that there is uncertainty in the DF, for a given ground motion. This uncertainty is due to a number of factors including variation of structural properties within the category of structure under consideration and variation in ground motion. In ATC-13, DF uncertainty about the mean was examined and found to be acceptably modeled by a Beta distribution although differences between the Beta, lognormal and normal probabilities were very small (see for example ATC-13, Fig. 7.9). For convenience herein, the lognormal rather than Beta distribution was chosen to represent the DF. The lognormal distribution offers the advantage of easier calculation using well-known polynomial approximations. Ideally a truncated lognormal distribution should be used to account for the fact that the DF can be no larger than 100. In the worst case this would have only changed the resulting hazard score by 5%. It should be noted that the lognormal distribution was the ATC-21 subcontractor's preference, and the Beta or other probability distributions could be used in developing structural scores.

For specified building classes (as defined in ATC-13) and for load levels ranging from MMI VI to XII, parameters of damage probability distributions were estimated from the "weighted statistics of the damage factor" given in Appendix G of ATC-13. Weights based on experience level and confidence of the experts were factored into the mean values of the low, best and high estimates (ML, MB, MH) found in that Appendix. For the development of hazard scores, the mean low and mean high estimates of the DF were taken as the 90% probability bounds on the damage factor distribution. The mean best estimate was interpreted as the median DF. Major damage was defined as a DF > .60 (greater than 60 percent damage).

For any lognormally distributed random variable, X, a related random variable, Y=ln(X), is normally distributed. The normal distribution is characterized by two parameters, its mean and standard deviation. The mean value of the normal distribution, m, can be equated to the median value of the lognormal distribution, x_m, by

$$m = \ln(x_m) \qquad \text{(B2)}$$

(Ang and Tang, 1975). Thus if it is assumed that the DF is lognormally distributed with the median = MB, the ln(DF) is normally distributed with mean m=ln(MB). The additional information needed to find the standard deviation, s, is provided by knowing that 90% of the probability distribution lies between ML and MH. Thus approximately 95% of the distribution is below the MH damage factor. From tables of the cumulative standard normal distribution, F(x), where x is the standard normal variate defined by $x=(y-m)/s$, it can be seen that F(x=1.64)=0.95. Therefore $(y-m)/s = 1.64$, where in this case y=ln(MH). The standard deviation may then be calculated from $s=(\ln(MH)-m)/1.64$. A similar calculation could be performed using the ML and the 5% cutoff. An average of these two values results in the following equation:

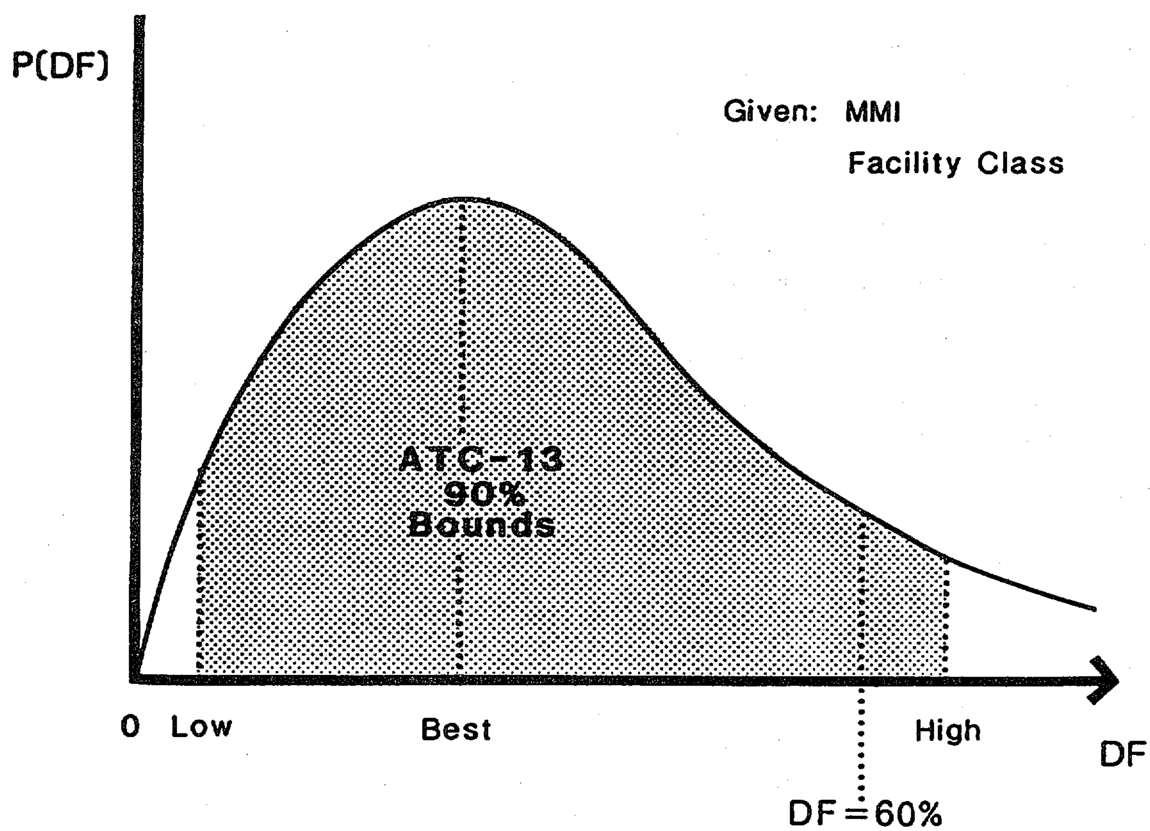
P(DF)
Given: MMI
Facility Class
ATC-13
90%
Bounds
0
Low
Best
High
DF
DF = 60%

Figure B1

$$s = (\ln(MH)-\ln(ML))/3.28 \qquad (B3)$$

A FORTRAN program was used to calculate the parameters m and s for various ATC-13 facility classes and all MMI levels.

To estimate probabilities of exceeding a 60% DF for various NEHRP areas, MMI was converted to EPA according to:

$$PGA = 10^{(MMI-1)/3} \qquad (B4)$$

where PGA is in gals (cm/sec^2), and

$$EPA = .75\ PGA \qquad (B5)$$

Equation B4 is a modification of the standard conversion given in Richter (1958) to arrive at PGA at the mid-point of the MMI value (rather than at the threshold, as given by Richter). Equation B5 is an approximate conversion (N. C. Donovan, personal communication). Only MMI VI to IX were considered, as this is the equivalent range of EPA under consideration in NEHRP Areas 1 to 7.

It was found that large uncertainty in DF for MMI VI and sometimes VII could lead to inconsistencies in the calculated probabilities of damage. To smooth these inconsistencies, $\log_{10}(s)$ was regressed against $\log_{10}$(EPA). The standard deviations of the damage probability distributions for various EPA levels were calculated from the resulting regression.

Once the parameters of the normal distribution were found, the probability of the DF being greater than 60%, Q, was calculated from the following polynomial approximation of the normal distribution (NBS 55, 1964). For the derivation of structural hazard scores, the standard variate $x = (\ln(60)-m)/s$:

$$Q(x) = Z(x)[b_1t+b_2t^2+b_3t^3+b_4t^4+b_5t^5] \qquad (B6)$$

where

$$Z(x) = (2\pi)^{-.5}*\exp(-x^2/2) \quad \text{and} \quad t = 1/(1+px)$$

and the constants are

$b_1 = .319381530$ $\quad b_2 = -.356563782$

$b_3 = 1.781477937$ $\quad b_4 = -1.821255978$

$b_5 = 1.330274429$ $\quad p = .2316419$

The resulting values of $\log_{10}(Q)$ (i.e. $\log_{10}[Pr(D >= 60\%)]$) corresponded to initial values of the Basic Structural Hazard score defined in Equation B1. These Structural Hazard scores are presented in Table B2 under NEHRP Map Area 7. These scores for the ATC-13 building classification were then used to determine the scores for the building classifications of ATC-14 (ATC, 1987), which are also employed here in ATC-21 (see left column, Table B1). In many cases, the correspondence of ATC-13 and ATC-14 is one-to-one (e.g., light metal). In some cases, several building types of ATC-13 correspond to one in ATC-14, and were therefore averaged to determine the ATC-21 score. In a few instances, due to inconsistencies still remaining despite the smoothing discussed above, these initial Basic Structural Hazard scores were adjusted on the basis of judgment, by consensus of the Project Engineering Panel. In order to extend the Structural Hazard scores for buildings constructed according to California building practices (which was all that ATC-13 considered) to other NEHRP Map Areas, two factors must be incorporated in the determination of the Structural Hazard score:

1. The seismic environment (i.e., lower EPA values) for NEHRP Map Areas 1 through 6 must be considered.
2. Buildings constructed in places other than the high seismicity portions of California, which probably have not been designed for the same seismic loadings and with the same seismic detailing as in California, must be considered. This latter aspect is termed the "non-California building" factor.

Table B2: Structural Hazard Score Values After Modification for Non-California Buildings (prior to rounding)
(Follows ATC-13 (ATC, 1985) building classifications)

EPA (g)	.05	.05	.10	.15	.20	.30	.40	LOW	MOD	HIGH
NEHRP Area	1	2	3	4	5	6	7	1,2	3,4	5,6,7
WOOD FRAME -LR	8.3	8.3	6.5	5.6	5.3	4.7	4.0	8.5	6.0	4.5
LIGHT METAL	6.6	6.6	6.4	5.8	5.5	5.3	5.7	6.5	6.0	5.5
URM - LR	3.1	3.1	2.0	2.0	1.7	1.4	1.2	3.0	2.0	1.5
URM - MR	2.5	2.5	1.9	1.5	1.3	1.1	1.0	2.5	1.5	1.0
TILT UP	4.8	4.8	4.9	3.1	2.9	1.9	2.4	5.0	3.5	2.0
BR STL FRAME - LR	3.2	3.2	3.7	3.1	3.4	3.0	3.1	3.0	3.5	3.0
BR STL FRAME - MR	2.1	2.1	2.7	2.3	2.8	2.6	2.9	2.0	2.5	3.0
BR STL FRAME - HR	2.3	2.3	2.6	1.9	2.3	1.9	2.0	2.5	2.5	2.0
STL PERIM. MRF - LR	4.3	4.3	5.4	4.7	4.9	5.5	5.4	4.5	5.0	5.5
STL PERIM. MRF - MR	3.7	3.7	4.5	3.7	3.8	4.1	3.9	3.5	4.0	4.0
STL PERIM. MRF - HR	3.6	3.6	3.5	2.7	2.6	2.7	2.4	3.5	3.0	2.5
STL DISTRIB MRF - LR	3.1	3.1	3.8	3.5	3.8	4.4	4.5	3.0	3.5	4.5
STL DISTRIB MRF - MR	3.0	3.0	3.8	3.3	3.5	3.8	3.7	3.0	3.5	4.0
STL DISTRIB MRF - HR	3.0	3.0	3.4	2.8	2.8	2.8	2.5	3.0	3.0	2.5
RCSW NO MRF - LR	5.4	5.4	5.4	3.9	4.6	4.0	3.5	5.5	4.5	4.0
RCSW NO MRF - MR	4.6	4.6	4.1	2.7	3.4	2.9	2.5	4.5	3.5	2.5
RCSW NO MRF - HR	3.5	3.5	3.2	2.1	2.5	2.1	1.8	3.5	2.5	2.0
URM INFILL - LR	2.8	2.8	2.1	1.6	1.3	1.2	1.1	3.0	1.5	1.0
URM INFILL - MR	2.5	2.5	1.7	1.2	1.1	1.1	1.1	2.5	1.5	1.0
URM INFILL - HR	2.3	2.3	1.5	1.1	1.0	1.0	1.1	2.5	1.0	1.0
ND RC MRF - LR	4.2	4.2	4.2	2.4	2.9	2.7	2.2	4.0	3.0	2.5
ND RC MRF - MR	3.9	3.9	3.7	2.3	2.2	2.0	1.7	4.0	2.5	2.0
ND RC MRF - HR	3.4	3.4	3.5	2.1	2.2	2.1	1.8	3.5	2.5	2.0
D RC MRF - LR	7.6	7.6	8.7	6.6	7.0	6.5	5.7	7.5	7.5	6.0
D RC MRF - MR	5.0	5.0	6.3	4.8	5.4	5.4	4.9	5.0	5.5	5.0
D RC MRF - HR	5.7	5.7	5.9	4.0	4.3	3.8	3.2	5.5	4.5	3.5
PC FRAME - LR	3.0	3.0	3.8	2.3	2.0	1.4	1.6	3.0	2.5	1.5
PC FRAME - MR	1.8	1.8	2.2	1.7	2.2	1.8	1.2	2.0	2.0	1.5
PC FRAME - HR	1.6	1.6	2.3	1.4	1.7	1.4	1.0	1.5	2.0	1.0
RM SW W/O MRF - LR	3.9	3.9	5.4	4.5	4.1	3.5	2.9	4.0	4.5	3.0
RM SW W/O MRF - MR	3.4	3.4	4.3	3.4	3.1	2.6	2.2	3.5	3.5	2.5
RM SW W/O MRF - HR	2.7	2.7	3.4	2.6	2.3	1.9	1.7	2.5	3.0	2.0
RM SW W/ MRF - LR	4.0	4.0	5.8	5.0	4.7	4.1	3.6	4.0	5.0	4.0
RM SW W/ MRF - MR	5.7	5.7	7.6	5.8	5.1	3.9	3.1	5.5	6.0	3.5
RM SW W/ MRF - HR	5.9	5.9	8.1	6.2	5.5	4.3	3.4	6.0	6.5	4.0
LONG SPAN	4.2	4.2	3.9	3.2	3.3	3.5	3.2	4.0	3.5	3.5

With regard to the first of these factors, to facilitate calculating the final Structural Hazard scores for the EPA loadings in NEHRP Areas 1 through 6, $\log_{10}[\log_{10}$(Structural Hazard Score)] was regressed against EPA and scores were calculated from the resulting regression. These values represent the values for a "California building" (i.e., designed and built according to standard California seismic practices) in a different NEHRP Map Area. The extension of the scoring system to structures outside of California (i.e., "non-California buildings") is discussed below.

B.2 Extension to Non-California Building Construction

Due to the nature of data compiled in ATC-13, the above Structural Hazard scores are appropriate for "average" buildings designed and built in California, subjected to seismic loadings appropriate for NEHRP Map Area 7. In regions where building practices differ significantly from California (i.e., NEHRP Map Area 7) building practices, the Structural Hazard score should be modified. It would be expected that in regions where seismic loading does not control the design, this would lead to an increase in the value of the Structural Hazard score.

An example of this "non-California building" effect might be a reinforced masonry (RM) building in NEHRP Map Area 3, where local building codes typically may not have required any design for seismic loading until recently, if at all. This is not to say that buildings in NEHRP Map Area have no lateral load (and hence seismic) capacity. Design for wind loads would provide some lateral load capacity, although lack of special details might result in relatively little ductility. However, interior masonry partitions (e.g., interior walls built of concrete masonry units, CMU) might typically be unreinforced, with ungrouted cells, for example. Although the building structure could thus be fairly classified as RM, failure and probable collapse of most of the interior walls would be a major life-safety hazard, as well as resulting in major property damage. Although the exterior walls are reinforced, they will likely lack details required in UBC Seismic Zones 3 and 4, and thus will likely have less ductility. Therefore, the Structural Hazard score in NEHRP Map Area 3 for this building type should be lower than it would be for a "California" building, if the seismic loading were the same. Given that the seismic loading in NEHRP Map Area 3 is less than in most of California, the actual resulting score may be higher or lower, depending on the seismic capacity/demand ratio.

Some building types, on the other hand, such as older unreinforced masonry (URM) may be no different in California than in most other parts of the United States, so that the seismic capacity is the same in many NEHRP areas. Since the seismic loading is less for most non-California map areas (e.g., NEHRP Map Areas 1, 2, 3), the seismic capacity/demand ratio increases for these type of buildings for NEHRP Map Areas 1, 2, 3. Similarly, building types whose seismic capacity is the same will have higher Basic Structural Hazard scores in the lower seismicity NEHRP Map Areas.

Quantification of the change in Structural Hazard score due to variations in regional seismicity can be treated in a rather straightforward manner, as outlined above. Changes in the Structural Hazard score due to variations in local design or building practices, as discussed above, however, is difficult because seismic experience for these regions is less, and expert opinion data similar to ATC-13 did not exist for non-California buildings. In the course of the development of the *ATC-21 Handbook* therefore, expert opinion was sought in order to extend the ATC-13 information to non-California building construction. Information was sought in a structured manner from experienced engineers in NEHRP Areas 1 to 6, asking them to compare the performance of specific building types in their regions to

California-designed buildings of the same type. After reviewing and comparing the responses, a composite of all responses for a region was sent to the experts, who were then asked, based on these composite results, for their final estimate of the seismic performance for each building type for their region.

Generally, for the same level of loading, the experts expected higher damage for buildings in their regions than for similar structures built in California, as might be expected. For a given NEHRP Map Area, although there was substantial scatter in these experts' responses, in most cases the responses could be interpreted such that the non-California building DF could be considered to differ by a constant multiple from the corresponding "California building" DF. That is, responses from all experts in each region were averaged and used to estimate the modification constant for each building type.

These modification constants (MC), presented in Table B3, were used to change the value of the mean best estimate from ATC-13 (MB) to a best estimate for each NEHRP Map Area (BENA) according to the following equation:

$$BENA = MC*MB \qquad (B7)$$

Keeping the standard deviation constant (as calculated in equation B3) and using the best estimate of the DF (BENA) from equation B7, Structural Hazard scores were calculated for each region using the methodology described in Section B.1. These structural scores are presented in Table B2, for each NEHRP Map Area.

Because the derived scores were based on expert opinion, and involved several approximations as discussed above, it was felt that the precision inherent in the Structural Hazard scores only warranted expressing these values to the nearest 0.5 (i.e., all were rounded to the nearest one half: .3 rounded to .5, 1.2 to 1.0 and so on). A comparison of scores for low rise (1 to 3 stories) and medium rise (4 to 7 stories) structures after rounding showed little or no difference for most building classes. Therefore, these values (before rounding) were averaged for low- and medium-rise buildings. This value, appropriate for low- and medium-rise buildings, is designated as the Basic Structural Hazard score. For high-rise construction (8+ stories), this is modified by a high-rise Performance Modification Factor (PMF). This high-rise PMF is a function of building class and was calculated by subtracting the Basic Structural Hazard score for low- and mid-rise buildings from that determined for high-rise buildings.

Lastly, a comparison of scores for different NEHRP Map Areas revealed very little difference of Structural Hazard scores for certain levels of seismicity. The scoring process was therefore simplified by grouping high, moderate, and low seismicity NEHRP areas together as follows:

Seismicity	NEHRP Areas
High	5, 6, 7
Moderate	3, 4
Low	1, 2

B.3 Sample Calculation of Basic Structural Hazard Scores

A sample calculation is presented here for ATC-13 facility class 1 (wood frame), based on data taken from Appendix G in ATC-13 (ATC, 1985), shown in Table B4. Although ATC-13 provided data for MMI VI to XII, the data for MMI greater than X do not correspond to the NEHRP Map effective peak accelerations. Therefore they were not included in developing the scores for this Rapid Screening Procedure (RSP).

Table B3: ATC-21 Round 2 Damage Factor Modification Constants

Structure Type	NEHRP Map Area 1,2	3	4	5	6
Wood Frame	1.0	1.3	1.3	1.2	1.0
Steel Moment Resisting Frame (S1)	1.9	1.2	1.4	1.3	1.0
Steel Frame with Steel Bracing or Concrete Shear Walls	1.9	1.2	1.4	1.1	1.1
Light Metal	1.1	1.1	1.3	1.3	1.2
Steel Frame or Concrete Frame with Unreinforced Masonry Infill Walls	1.2	1.2	1.3	1.3	1.2
Concrete Moment Resisting Frame	2.2	1.3	1.5	1.2	1.0
Concrete Shear Wall	1.7	1.3	1.5	1.1	1.0
Tilt-up (PC1)	2.0	1.2	1.5	1.3	1.4
Precast Concrete Frames	2.9	1.1	1.8	1.2	1.3
Reinforced Masonry (RM)	2.9	1.1	1.3	1.1	1.0
Unreinforced Masonry	1.1	1.2	1.0	1.0	1.0

The mean and standard deviation of the Normal distribution are calculated from equations B2 and B3 with the results shown in Table B5.

A regression of $\log_{10}(s)$ versus $\log_{10}(\text{EPA})$ yields the following equation:

$$\log_{10}(s) = -0.409 - 0.192*\log_{10}(\text{EPA})$$

Using values of s obtained from the above equation and the polynomial approximation of the normal distribution given in Equation B6, probabilities of exceeding 60 percent damage were calculated for EPA values of .35 and lower. The resulting probabilities and hazard scores are shown in Table B6.

Finally $\log_{10}[\log_{10}(\text{BSH})]$ was regressed against EPA resulting in the following equation:

$$\log_{10}[\log_{10}(\text{BSH})] = -0.0101 - 0.532*\text{EPA}$$

Values of the Basic Structural Hazard score for California buildings calculated from the above equation for specified EPA are shown below:

EPA(g)	BSH
0.05	8.30
0.10	7.32
0.15	6.50
0.20	5.82
0.30	4.75
0.40	3.97

BSH = 3.97 corresponding to an EPA of 0.4g is the score for NEHRP Map Area 7. To calculate BSH for other NEHRP Map Areas the same process must be used with the modified mean damage factor described in Section B.2. For wood-frame structures the modification constants developed from the questionnaires are:

NEHRP Map Area	1	2	3	4	5	6
Modification Constant	1	1	1.3	1.3	1.2	1

Using these constants, the modified median damage factors for NEHRP Map Area 3, for example, are (see Equation B7):

MMI	VI	VII	VIII	IX
Median DF	1.0	1.9	5.9	11.5

Repeating the same procedure using the natural log of these median DF to calculate the mean of the normal distribution and the same standard deviations shown above, the Structural Hazard score is calculated for each NEHRP Map Area. The final values for the example given here (wood-frame buildings), before and after rounding to the nearest half, are shown in Table B7 for this example of wood buildings and in Table B2 for all building types.

Finally, because there appeared to be little variation between some NEHRP Map Areas, these were grouped together into three areas, with corresponding BSH values (see Table B1). For the example of wood-frame buildings, resulting values are:

	NEHRP Map Areas	BSH
LOW	1, 2	8.5
MODERATE	3, 4	6.0
HIGH	5, 6, 7	4.5

Table B4

MMI	PGA (g)	EPA (g)	Damage Factor (%) Mean Low (ML)	Mean Best (MB)	Mean High (MH)
VI	0.05	0.04	0.2	0.8	2.6
VII	0.10	0.08	0.7	1.5	4.8
VIII	0.22	0.16	1.8	4.7	11.0
IX	0.47	0.35	4.5	9.2	19.7

Table B5

EPA (g)	ln (ML)	ln (MH)	*s* (std. dev.)	*m* (mean=ln{MB})
0.04	-1.609	0.956	0.782	-0.223
0.08	-0.356	1.569	0.587	0.405
0.16	0.588	2.398	0.552	1.548
0.35	1.504	2.981	0.450	2.219

Table B6

EPA	$Pr(D \geq 60)$	BSH
0.04	2.69×10^{-9}	8.57
0.08	3.80×10^{-9}	8.42
0.16	1.91×10^{-6}	5.72
0.35	4.07×10^{-5}	4.39

Table B7

NEHRP	EPA (g)	Final Values	BSH
1	0.05	8.3	8.5
2	0.05	8.3	8.5
3	0.10	6.45	6.50
4	0.15	5.6	5.5
5	0.20	5.26	5.5
6	0.30	4.75	5.0
7	0.40	3.97	4.0

The final resulting values of Basic Structural Hazard score presented in Table B1 are intended for use nationwide. However, local building officials may feel that building practice in their community differs significantly from the conditions typified by the Modification Constants (MCs) in Table B3. The computer source code and data employed for this study is therefore furnished (Figure B2) so that alternative MCs may be employed to generate BSH scores based on an alternative set of MCs. An alternative computation might be conducted, for example, if a community in NEHRP Map Area 5 (e.g., Memphis, TN) felt that the MCs for Map Area 4 were more appropriate. Example resulting BSH scores would then be:

Wood	5.0
Light Metal	5.5
URM	1.5
Tilt-up	2.5

Note that if non-standard BSH scores are thus computed, PMFs should be reevaluated. In most cases, however, the BSH scores in Table B1 should be appropriate.

The interpretation of these values is rather straightforward—a value of 8.5 in Low seismicity areas indicates that on average wood-frame buildings, when subjected to EPA of 0.05g, have a probability of sustaining major damage (i.e., damage greater than 60 percent of their replacement value) of $10^{-8.5}$. In High seismicity areas, where the EPA is 0.3g to 0.4g, the probability of sustaining major damage is $10^{-4.5}$.

Thus, BSH has a straightforward interpretation: if BSH is 1, the probability of major damage is 1 in 10, if BSH is 2, the probability of major damage is 1 in 100, if BSH is 3, the probability of major damage is 1 in 1000, and so on.

It should be noted that BSH as defined and used here is similar to the structural reliability index, Beta (Hasofer and Lind, 1974), which can be thought of as the standard variate of the probability of failure (if the basic variables are normally distributed, which is often a good approximation). For values of BSH between about 0 and 5 (typically the range of interest herein), Beta and BSH are approximately equal. Further, it should be noted that research into the Beta values inherent in present building codes (NBS 577, 1980) indicates that Beta (or BSH) values of 3 for gravity loads and about 1.75 for earthquake loads are typical.

B.4 Performance Modification Factors

There are a number of factors that can modify the seismic performance of a structure causing the performance of an individual building to differ from the average. These factors basically are related to significant deviations from the normal structural practice or conditions, or have to do with the effects of soil amplification on the expected ground motion.

Deviations from the normal structural practice or conditions, in the case of wood frame buildings for example, can include deterioration of the basic wood material, due to pests (e.g., termites) or rot, or basic structural layout, such as unbraced cripple walls or lack of bolting of the wood structure to the foundation. The number and variety of such performance modification factors, for all types of buildings, is very large, and many of these cannot be detected from the street on the basis of a rapid visual inspection. Because of this, based on querying of experts and checklists from ATC-14, a limited number of the most significant factors were identified. Factors considered for this RSP were limited to those having an especially severe impact on seismic performance. Those that could not be readily observed from the street were eliminated. The performance modification factors were assigned values, based on judgment, such that when

```
C THIS PROGRAM FINDS THE STRUCTURAL SCORES FOR THE ATC21 HANDBOOK
C USING DATA FROM ATC13
C A LOGNORMAL DISTRIBUTION FOR DAMAGE IS ASSUMED
C T. Anagnos and C. Scawthorn 1987,1988
C----------------------------------------------------
C
C
     dimension x(10),y(10),epa(7)
     open(5,file='atcs.dat',status='old')
     open(6,file='outputcs',status='old')
     data epa /.05,.05,.1,.15,.2,.3,.4/
     write(6,200) (epa(i),i=1,7)
     write(6,210) (i,i=1,7)
200  format('EPA',17x,7(f5.2),'    LOW  MOD  HIGH      M2
H2')
 210  format('NEHRP Area          ',7(i5))
 202     FORMAT (' ')
         WRITE (6,202)
      read(5,*) ntype
      do 1 i=1,ntype
          call dfread
 1    continue
      end
c---------------------------------------------------
subroutine dfread
dimension pga(7),s(7),p(7),stvar(7),sigma(7),x(7),y(7)
DIMENSION dmodfy(7),dbest(7),sfinal(7), bldg(10)
      real lnlow(7),lnbest(7),lnhigh(7),epa(10)
      read(5,100) (bldg(i),i=1,6)
100   format(6a4)
c READ MODIFICATION FACTORS FOR EACH NEHRP AREA
      read(5,*) (dmodfy(j),j=1,7)
C CONVERT MMI TO PGA
      do 2 i=1,7
        read(5,*) xmmi,dlow,dbest(i),dhigh
        pga(i)=10**(((xmmi+0.5)/3.)-0.5)/981.
        lnlow(i)=alog(dlow)
      lnhigh(i)=alog(dhigh)
 2    continue
      do 50 nehrp=1,7
      do 7 i=1,7
      temp=dbest(i)/dmodfy(nehrp)
      if (temp.gt.100.) temp=100.
        lnbest(i)=alog(temp)
        x(i)=alog10(pga(i))
 7    continue
      do 3 i=1,7
 3    continue
 201  format(' ',4(f10.5,1x))
C COMPUTE STANDARD DEVIATION OF THE LOGNORMAL DISTRIBUTION
      do 4 i=1,7
        sigma(i)=(lnhigh(i)-lnlow(i))/3.28
        y(i)=alog10(sigma(i))
 4    continue
```

Figure B2

```
     FORTRAN PROGRAM NEHRP.FOR
     PAGE 2

C REGRESS LOG(SIGMA) AGAINST LOG(PGA)
      n=7
      call regres(x,y,n,a,b)
 202  format(' a=',f8.3,'b= ',f8.3)
C COMPUTE PROBABILITIES OF EXCEEDANCE USING AN APPROXIMATION
C OF THE LOGNORMAL DISTRIBUTION
C STVAR = STANDARD VARIATE
      c1=.31938153
      c2=-.356563782
      c3=1.781477937
      c4=-1.821255978
      c5=1.330274429
      do 5 i=1,7
      stvar(i)=(alog(60.)-lnbest(i))/10**(a+b*x(i))
      t=1./(1.+stvar(i)*0.2316419)
c Approximation is invalid for large negative standard
c variates
      if(stvar(i).lt.-3.) p(i)=1.0
      if(stvar(i).lt.-3.) goto 8
      ctot=c1*t+c2*t**2+c3*t**3+c4*t**4+c5*t**5
      p(i)=exp(-.5*stvar(i)**2)/sqrt(6.283185308)*ctot
C ACCOUNT FOR ROUND OFF ERROR IN THE APPROXIMATION
 8     continue
      if(p(i).gt.1.0) p(i)=1.0
      if(p(i).lt.0.0) p(i)=0.0
C CALCULATE THE STRUCTURAL SCORE "S"
       s(i)=-1.*alog10(p(i))
 5    continue
C FIND WHERE STRUCTURAL SCORE BECOMES NEGATIVE
        marker=0
      do 6 j=1,4
      temp=alog10(s(j))
       if(temp.le.0.0) marker=j
       if (temp.le.0.0) goto 10
       y(j)=alog10(temp)
 6     continue
       goto 11
 10    continue
 11    continue
       n=4
       if(marker.ne.0) n=marker-1
C REGRESS LOG(S) AGAINST PGA
      call regress(pga,y,n,ascor,bscor)
       call finscr(ascor,bscor,nehrp,score)
       sfinal(nehrp)=score
 510   format(' a=',f10.3,'b= ',f10.3)
 204   format(' x=',f8.5,'p=',f8.5,'s=',f8.5)
 50    continue
       xl=.5*nint((sfinal(1)+sfinal(2))/(2*.5))
       xm=.5*nint((sfinal(3)+sfinal(4)+sfinal(5))/(3*.5))
       xh=.5*nint((sfinal(6)+sfinal(7))/(2*.5))
       xm2=.5*nint((sfinal(3)+sfinal(4))/(2*.5))
       xh2=.5*nint((sfinal(5)+sfinal(6)+sfinal(7))/(3*.5))
200  format(' ',10a4)
```

Figure B2

FORTRAN PROGRAM NEHRP.FOR
PAGE 3

```
210   format(' ',5A4,7(f5.1),3x,3f5.1,3x,2f5.1)
      write(6,210)
      (bldg(i),i=1,5),(sfinal(i),i=1,7),xl,xm,xh,xm2,xh2
      return
      end
c-----------------------------------------------------------
c SUBROUTINE TO CALCULATE THE FINAL SCORE FOR EA NEHRP AREA
c-----------------------------------------------------------
      subroutine finscr(a,b,narea,score)
      dimension epa(7),s(7)
      data epa/.05,.05,.1,.15,.2,.3,.4/
      do 1 i=1,7
       s(i)=10**(10**(a+b*epa(i)*4/3))
   1  continue
      score=s(narea)
 200  format(' nehrp area',7(i5,1x))
 210  format(' score     ',7(f5.2,1x))
      return
       end
c-----------------------------------------------
C SUBROUTINE TO PERFORM LINEAR REGRESSION AND PROVIDE THE
C RESULTING CONSTANTS
C-----------------------------------------------
      subroutine regres(x,y,n,a,b)
      dimension x(10),y(10)
 500 format(' x',10f10.6)
 501 format(' y',10f10.6)
      sumx=0.0
      sumxy=0.0
      sumy=0.0
      sumx2=0.0
      do 1 i=1,n
      sumx=sumx+x(i)
      sumx2=sumx2+x(i)**2
      sumy=sumy+y(i)
      sumxy=sumxy+x(i)*y(i)
 1    continue
      b=(sumxy-sumx*sumy/n)/(sumx2-sumx*sumx/n)
      a=(sumy-b*sumx)/n
      return
      end
```

Figure B2

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WOOD FRAME - LR

1 1 .8 .8 .87 1 1

6	0.20	0.80	2.60
7	0.70	1.50	4.80
8	1.80	4.70	11.00
9	4.50	9.20	19.70
10	8.80	19.80	39.70
11	14.40	24.40	47.30
12	23.70	37.30	61.30

LIGHT METAL

.9 .9 .9 .8 .77 .83 1

6	0.01	0.40	1.60
7	0.50	1.10	2.70
8	0.90	2.10	5.70
9	2.10	5.60	10.50
10	6.00	12.90	23.50
11	9.80	22.30	34.40
12	17.60	31.30	44.00

URM - LR

.9 .9 .82 1 1 1 1

6	0.90	3.10	7.50
7	3.30	10.10	26.40
8	8.90	22.50	48.50
9	22.10	41.60	74.90
10	41.90	64.60	93.60
11	57.20	78.30	97.30
12	72.70	89.60	100.0

URM - MR

.9 .9 .82 1 1 1 1

6	1.20	4.60	10.90
7	2.60	11.40	31.30
8	12.70	28.80	55.00
9	28.80	51.40	77.30
10	45.80	71.70	94.80
11	62.00	83.00	98.30
12	74.90	91.10	100.0

TILT UP

.5 .5 .85 .68 .77 .7 1

6	0.40	1.50	4.20
7	1.80	4.20	9.60
8	4.00	10.60	18.20
9	9.10	18.50	31.60
10	15.20	28.70	49.20
11	25.60	45.00	69.40
12	35.60	62.50	80.20

BR STL FRAME -LR

.53 .53 .85 .7 .91 .87 1

6	0.01	0.60	2.40
7	0.40	1.80	5.00
8	1.20	5.10	10.30
9	4.60	10.10	18.70
10	7.90	15.80	27.40
11	13.90	27.00	43.40
12	19.60	38.80	53.90

BR STL FRAME -MR

.53 .53 .85 .7 .91 .87 1

6	0.01	0.80	2.90
7	0.40	5.80	6.50
8	2.20	7.00	13.50
9	6.20	11.90	22.10
10	10.50	20.40	32.80
11	17.00	30.10	49.60
12	23.00	41.80	62.40

BR STL FRAME -HR

.53 .53 .85 .7 .91 .87 1

6	0.01	0.90	4.90
7	0.70	5.40	10.20
8	3.90	10.20	21.80
9	10.00	17.70	26.10
10	14.40	22.80	40.30
11	20.60	37.80	61.20
12	27.60	50.50	77.50

STL PERIM. MRF -LR

.5 .5 .85 .7 .8 1 1

6	0.01	0.70	2.20
7	0.50	1.70	3.90
8	2.00	3.80	7.90
9	3.70	7.20	11.50
10	6.90	13.90	20.90
11	10.10	22.20	32.20
12	16.80	31.40	44.10

STL PERIM. MRF -MR

.5 .5 .85 .7 .8 1 1

6	0.01	0.70	2.50
7	0.70	2.10	5.10
8	1.60	4.40	9.80
9	4.30	8.90	15.80
10	8.00	15.70	24.60
11	12.00	28.20	40.30
12	17.10	36.40	51.10

STL PERIM. MRF -HR

.5 .5 .85 .7 .8 1 1

6	0.01	0.70	3.50
7	0.90	2.40	7.30
8	2.30	6.20	14.20
9	5.30	14.50	24.50
10	9.60	19.80	31.50
11	17.00	36.70	50.50
12	23.40	44.50	59.10

STL DISTRIB MRF-LR

.5 .5 .85 .7 .8 1 1

6	0.01	0.40	1.90
7	0.10	1.40	4.20
8	1.10	2.90	7.60
9	2.80	5.80	12.10
10	4.70	10.80	20.10
11	7.10	19.70	31.00
12	18.60	32.50	44.10

STL DISTRIB MRF-MR

.5 .5 .85 .7 .8 1 1

6	0.01	0.80	2.70
7	0.30	1.70	4.80
8	1.50	4.30	9.60
9	3.20	7.10	14.80
10	5.50	12.60	19.30
11	8.40	19.60	33.70
12	11.50	30.30	42.10

STL DISTRIB MRF-HR

.5 .5 .85 .7 .8 1 1

6	0.01	0.50	2.70
7	0.40	2.40	6.50
8	1.70	4.90	12.70
9	3.30	9.60	18.60
10	6.60	16.30	26.40
11	8.40	24.20	41.40
12	11.80	32.30	50.20

RCSW NO MRF - LR

.6 .6 .8 .65 .91 .97 1

6	0.10	0.50	1.90
7	0.80	2.80	6.30
8	2.60	6.60	12.50
9	5.60	13.00	22.00
10	11.50	23.60	34.10
11	20.20	35.50	51.20
12	31.30	47.60	61.90

RCSW NO MRF - MR

.6 .6 .8 .65 .91 .97 1

6	0.20	1.00	2.80
7	0.60	3.70	7.80
8	3.30	8.80	16.10
9	8.00	17.50	29.50
10	16.40	28.90	44.70
11	22.60	39.50	57.90
12	33.10	49.80	70.40

RCSW NO MRF - HR

.6 .6 .8 .65 .91 .97 1

6	0.20	1.20	3.00
7	1.00	5.60	10.90
8	4.10	11.80	21.40
9	10.50	24.80	39.00
10	26.10	37.70	57.70
11	36.90	54.00	75.00
12	48.30	67.10	88.20

URM INFILL - LR

.83 .83 .82 .78 .77 .85 1

6	0.20	1.70	6.80
7	1.70	5.80	18.90
8	3.60	14.10	36.60
9	11.60	28.50	58.40
10	21.50	44.00	79.40
11	32.60	60.20	95.40
12	47.20	76.10	99.99

URM INFILL - MR

.83 .83 .82 .78 .77 .85 1

6	0.60	3.40	10.30
7	1.80	8.20	23.20
8	7.20	20.60	40.30
9	14.50	33.60	58.80
10	25.60	47.30	80.40
11	41.60	68.00	94.80
12	60.30	80.70	99.20

URM INFILL - HR

.83 .83 .82 .78 .77 .85 1

6	1.30	4.80	14.70
7	2.30	11.00	28.00
8	8.70	23.50	48.40
9	18.70	43.90	67.40
10	33.60	56.20	89.80
11	44.80	68.90	99.99
12	60.40	76.90	99.99

ND RC MRF - LR

.45 .45 .8 .65 .83 .97 1

6	0.20	1.30	3.60
7	1.90	4.20	10.10
8	5.40	12.10	21.80
9	12.80	21.10	38.20
10	17.50	31.80	50.80
11	27.20	47.50	65.60
12	42.40	62.00	81.40

ND RC MRF - MR

.45 .45 .8 .65 .83 .97 1

6	0.40	1.70	3.90
7	2.50	5.10	14.80
8	5.70	13.00	25.70
9	13.70	26.50	45.50
10	21.40	35.70	58.00
11	33.50	51.90	74.20
12	47.80	67.40	92.60

ND RC MRF - HR

.45 .45 .8 .65 .83 .97 1

6	0.40	1.70	3.50
7	1.70	5.40	13.40
8	6.00	13.30	28.00
9	12.60	25.30	44.90
10	23.70	40.50	65.20
11	33.70	55.30	80.30
12	54.00	75.80	94.90

D RC MRF - LR

.45 .45 .8 .65 .83 .97 1

6	0.20	0.40	1.50
7	0.70	1.70	4.70
8	2.10	4.10	10.40
9	4.00	9.20	16.90
10	8.70	17.50	26.60
11	15.30	25.90	36.30
12	28.30	41.90	51.70

D RC MRF - MR

.45 .45 .8 .65 .83 .97 1

6	0.40	1.30	3.30
7	1.30	3.40	6.90
8	2.30	5.80	12.60
9	5.40	10.80	20.10
10	8.60	16.90	26.30
11	16.80	28.40	40.40
12	24.10	37.10	51.50

D RC MRF - HR

.45 .45 .8 .65 .83 .97 1

6	0.50	1.80	3.90
7	1.50	3.20	7.80
8	3.10	6.90	17.50
9	6.10	13.70	24.70
10	10.90	21.50	33.60
11	14.80	31.80	47.20
12	19.50	38.60	56.80

PC FRAME -LR

.35 .35 .9 .57 .83 .8 1

6	0.10	1.10	4.20
7	0.80	2.80	8.40
8	3.20	8.00	18.90
9	10.00	23.20	33.90
10	18.90	37.60	56.90
11	24.20	48.70	68.60
12	32.10	60.00	83.90

PC FRAME -MR

.35 .35 .9 .57 .83 .8 1

6	.001	1.10	4.90
7	1.10	3.40	10.10
8	3.30	8.40	21.60
9	10.50	27.20	34.50
10	24.20	43.10	62.90
11	29.30	53.70	78.30
12	35.70	68.70	93.70

PC FRAME - HR

.35 .35 .9 .57 .83 .8 1

6	.001	1.10	5.00
7	1.00	4.10	9.80
8	3.30	10.10	24.60
9	11.90	29.60	39.70
10	24.70	44.30	63.90
11	29.90	54.60	79.60
12	35.00	69.70	99.50

RM SW W/O MRF - LR

.35 .35 .9 .85 .91 .97 1

6	0.20	0.80	2.30
7	0.90	2.90	7.10
8	2.20	6.00	14.20
9	4.60	13.50	27.20
10	11.90	23.20	40.50
11	21.50	41.90	62.20
12	31.80	52.30	72.90

RM SW W/O MRF - MR

.35 .35 .9 .85 .91 .97 1

6	0.20	1.20	3.20
7	1.50	3.50	8.90
8	2.90	9.90	20.20
9	6.60	17.90	32.70
10	15.80	30.50	51.60
11	26.90	46.10	73.60
12	38.50	59.70	89.50

RM SW W/O MRF - HR

.35 .35 .9 .85 .91 .97 1

6	0.30	1.20	4.00
7	1.60	5.10	12.50
8	3.40	13.30	25.90
9	11.10	22.50	44.10
10	19.20	36.80	65.40
11	31.30	55.00	82.80
12	44.00	70.50	97.20

RM SW W/ MRF - LR

.35 .35 .9 .85 .91 .97 1

6	0.10	1.00	2.40
7	0.80	2.40	7.60
8	3.10	5.90	12.40
9	6.50	11.90	20.10
10	10.70	18.40	33.40
11	19.80	30.90	59.00
12	29.40	51.30	79.20

RM SW W/ MRF - MR

.35 .35 .9 .85 .91 .97 1

6	0.60	1.40	2.90
7	1.60	3.50	8.00
8	3.70	8.80	16.80
9	8.10	15.20	27.20
10	13.00	23.70	45.00
11	22.80	39.40	69.40
12	37.00	57.80	87.50

RM SW W/ MRF - HR

.35 .35 .9 .85 .91 .97 1

6	0.80	1.60	3.20
7	1.20	2.90	7.10
8	3.10	7.10	14.80
9	6.80	13.20	25.20
10	11.20	24.30	47.40
11	19.40	40.10	69.70
12	36.00	66.50	89.90

LONG SPAN

1 1 .9 .7 .83 1 1

6	0.01	0.30	1.60
7	0.20	1.10	5.50
8	1.00	4.00	10.60
9	3.60	9.00	17.20
10	7.60	16.10	33.00
11	16.00	29.70	45.90
12	27.50	45.70	62.50

Figure B2

added to the Basic Structural Hazard scores above, (or subtracted, depending on whether their effect was to decrease or increase the probability of major damage) the resulting modified score would approximate the probability of major damage given the presence of that factor.

The final list of performance modification factors applicable to the rapid visual screening methodology is:

Poor condition: deterioration of structural materials

Plan irregularities: buildings with reentrant corners and long narrow wings such as L, H, or E-shaped buildings

Vertical irregularities: buildings with major cantilevers, major setbacks, or other structural features that would cause a significant change in stiffness in the upper stories of the building

Soft story: structural features that would result in a major decrease in the lateral load resisting system's stiffness at one floor - typically at the ground floor due to large openings or tall stories for commercial purposes

Pounding: inadequate seismic clearance between adjacent buildings - to be applied only when adjacent building floor heights differ so that building A's floors will impact building B's columns at locations away from B's floor levels and thus weaken the columns..

Large heavy cladding: precast concrete or stone panels that might be inadequately anchored to the outside of a building and thus cause a falling hazard (only applies to buildings designed prior to the adoption of the local ordinances requiring improved seismic anchorage).

Short columns: columns designed as having a full story height but which because of wall sections or deep spandrel beams between the columns have an effective height much less than the full story height. This causes brittle failure of the columns and potential collapse.

Torsion: corner or wedge buildings or any type of building in which the lateral load resisting system is highly non-symmetric or concentrated at some distance from the center of gravity of the building.

Soil profile: soil effects were treated by employing the UBC and NEHRP classification of "standard" soil profiles SL1, SL2 and SL3, where SL1 is rock, or stable soil deposits of sands, gravels or stiff clays less than 200 ft. in thickness; SL2 is deep cohesionless or stiff clay conditions exceeding 200 ft. in thickness; and SL3 is soft to medium stiff clays or sands, greater than 30 ft. in thickness. Present building code practice is to apply an increase in lateral load of 20% for SL2 profiles and 50% for SL3 profiles, over the basic design lateral load. This approach was used herein, and these factors were applied to the EPA for each NEHRP Map Area to determine the impact on the Basic Structural Hazard score. It was determined that this impact could generally be accounted for by a PMF of 0.3 for SL2 profiles, and 0.6 for SL3 profiles. Further, to account for resonance type effects, based on judgment the 0.6 PMF for SL3 profiles was increased to 0.8 if the building in questions was 8 to 20 stories in height.

Benchmark Year: year in which modern seismic design revisions were enforced by the local jurisdiction. Buildings built after this year are assumed to be seismically adequate unless exhibiting a major defect as discussed above.

Unbraced parapets, overhangs, chimneys and other non-structural falling hazards, while potentially posing life safety problems, do not cause structural collapse and therefore have not been assigned performance modifiers. Similarly, weak masonry foundations, unbraced cripple walls and houses not bolted to their foundations will cause significant structural damage but will probably not lead to structural collapse. Therefore the data collection form contains a section where this type of information may be noted, and the owner notified.

It was also determined that certain building types were not significantly affected by some of the factors. Therefore the modifiers do not apply to all building types. The actual values of the PMFs, specific to each NEHRP Map Area, may be seen on the data collection forms, Figures B3a,b,c.

ATC-21/ (NEHRP Map Areas 1,2 Low)

Rapid Visual Screening of Seismically Hazardous Buildings

Scale:

Address ______________________

______________ Zip ______

Other Identifiers ______________________

No. Stories __________ Year Built __________

Inspector __________ Date __________

Total Floor Area (sq. ft) __________

Building Name ______________________

Use ______________________

(Peel-off label)

INSTANT PHOTO

OCCUPANCY

Occupancy	No. Persons
Residential Commercial Office Industrial Pub. Assem. School Govt. Bldg. Emer. Serv. Historic Bldg.	0–10 11–100 100+

Non Structural Falling Hazard ☐

DATA CONFIDENCE

* = Estimated, Subjective, or Unreliable Data

DNK = Do Not Know

STRUCTURAL SCORES AND MODIFIERS

BUILDING TYPE	W	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	C1 (MRF)	C2 (SW)	C3/S5 (URM INF)	PC1 (TU)	PC2	RM	URM
Basic Score	**8.5**	**3.5**	**2.5**	**6.5**	**4.5**	**4.0**	**4.0**	**3.0**	**3.5**	**2.5**	**4.0**	**2.5**
High Rise	N/A	0	0	N/A	-0.5	-0.5	-0.5	-0.5	N/A	-1.0	-1.5	-0.5
Poor Condition	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Vert. Irregularity	-0.5	-0.5	-0.5	-0.5	-1.0	-1.0	-0.5	-1.0	-1.0	-1.0	-0.5	-1.0
Soft Story	-1.0	-2.0	-2.0	-1.0	-2.0	-2.0	-2.0	-1.0	-1.0	-1.0	-2.0	-1.0
Torsion	-1.0	-2.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
Plan Irregularity	-1.0	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0
Pounding	N/A	-0.5	-0.5	N/A	-0.5	-0.5	N/A	N/A	N/A	-0.5	N/A	N/A
Large Heavy Cladding	N/A	-2.0	N/A	N/A	N/A	-1.0	N/A	N/A	N/A	-1.0	N/A	N/A
Short Columns	N/A	N/A	N/A	N/A	N/A	-1.0	-1.0	-1.0	N/A	-1.0	N/A	N/A
Post Benchmark Year	+2.0	+2.0	+2.0	+2.0	+2.0	+2.0	+2.0	N/A	+2.0	+2.0	+2.0	N/A
SL2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
SL3	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
SL3 & 8 to 20 stories	N/A	-0.8	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	N/A	-0.8	-0.8	-0.8
FINAL SCORE												

COMMENTS

ATC13LOW
30032.01

Detailed Evaluation Required?

YES NO

Figure B3a

ATC-21/ (NEHRP Map Areas 3,4, Moderate)

Rapid Visual Screening of Seismically Hazardous Buildings

Address ______________________ Zip ________

Other Identifiers ______________________

No. Stories __________ Year Built __________

Inspector __________ Date __________

Total Floor Area (sq. ft) ______________________

Building Name ______________________

Use ______________________

(Peel-off label)

Scale:

INSTANT PHOTO

OCCUPANCY	No. Persons
Residential	
Commercial	0–10
Office	11–100
Industrial	100+
Pub. Assem.	
School	
Govt. Bldg.	
Emer. Serv.	
Historic Bldg.	

Non Structural Falling Hazard ☐

DATA CONFIDENCE

* = Estimated, Subjective, or Unreliable Data

DNK = Do Not Know

STRUCTURAL SCORES AND MODIFIERS

BUILDING TYPE	W	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	C1 (MRF)	C2 (SW)	C3/S5 (URM INF)	PC1 (TU)	PC2	RM	URM
Basic Score	6.0	4.0	3.0	6.0	4.0	3.0	3.5	2.0	3.5	2.0	3.5	2.0
High Rise	N/A	-1.0	-0.5	N/A	-1.0	-0.5	-1.0	-1.0	N/A	0	-0.5	-0.5
Poor Condition	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Vert. Irregularity	-0.5	-0.5	-0.5	-0.5	-1.0	-1.0	-0.5	-1.0	-1.0	-1.0	-0.5	-1.0
Soft Story	-1.0	-2.0	-2.0	-1.0	-2.0	-2.0	-2.0	-1.0	-1.0	-1.0	-2.0	-1.0
Torsion	-1.0	-2.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
Plan Irregularity	-1.0	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0
Pounding	N/A	-0.5	-0.5	N/A	-0.5	-0.5	N/A	N/A	N/A	-0.5	N/A	N/A
Large Heavy Cladding	N/A	-2.0	N/A	N/A	N/A	-1.0	N/A	N/A	N/A	-1.0	N/A	N/A
Short Columns	N/A	N/A	N/A	N/A	N/A	-1.0	-1.0	-1.0	N/A	-1.0	N/A	N/A
Post Benchmark Year	+2.0	+2.0	+2.0	+2.0	+2.0	+2.0	+2.0	N/A	+2.0	+2.0	+2.0	N/A
SL2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
SL3	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
SL3 & 8 to 20 stories	N/A	-0.8	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	N/A	-0.8	-0.8	-0.8

FINAL SCORE

COMMENTS

Detailed Evaluation Required?

YES NO

Figure B3b

ATC-21/ (NEHRP Map Areas 5,6,7 High)

Rapid Visual Screening of Seismically Hazardous Buildings

Scale:

Address ____________________
____________________ Zip ________
Other Identifiers ____________________
No. Stories ____________ Year Built ________
Inspector ____________ Date ________
Total Floor Area (sq. ft) ____________________
Building Name ____________________
Use ____________________

(Peel-off label)

INSTANT PHOTO

OCCUPANCY

	No. Persons
Residential	0–10
Commercial	11–100
Office	100+
Industrial	
Pub. Assem.	
School	
Govt. Bldg.	
Emer. Serv.	
Historic Bldg.	

Non Structural Falling Hazard ☐

DATA CONFIDENCE

* = Estimated, Subjective, or Unreliable Data

DNK = Do Not Know

STRUCTURAL SCORES AND MODIFIERS

BUILDING TYPE	W	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	C1 (MRF)	C2 (SW)	C3/S5 (URM INF)	PC1 (TU)	PC2	RM	URM
Basic Score	**4.5**	**4.5**	**3.0**	**5.5**	**3.5**	**2.0**	**3.0**	**1.5**	**2.0**	**1.5**	**3.0**	**1.0**
High Rise	N/A	-2.0	-1.0	N/A	-1.0	-1.0	-1.0	-0.5	N/A	-0.5	-1.0	-0.5
Poor Condition	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Vert. Irregularity	-0.5	-0.5	-0.5	-0.5	-0.5	-1.0	-0.5	-0.5	-1.0	-1.0	-0.5	-0.5
Soft Story	-1.0	-2.5	-2.0	-1.0	-2.0	-2.0	-2.0	-1.0	-1.0	-2.0	-2.0	-1.0
Torsion	-1.0	-2.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
Plan Irregularity	-1.0	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0
Pounding	N/A	-0.5	-0.5	N/A	-0.5	-0.5	N/A	N/A	N/A	-0.5	N/A	N/A
Large Heavy Cladding	N/A	-2.0	N/A	N/A	N/A	-1.0	N/A	N/A	N/A	-1.0	N/A	N/A
Short Columns	N/A	N/A	N/A	N/A	N/A	-1.0	-1.0	-1.0	N/A	-1.0	N/A	N/A
Post Benchmark Year	+2.0	+2.0	+2.0	+2.0	+2.0	+2.0	+2.0	N/A	+2.0	+2.0	+2.0	N/A
SL2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
SL3	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
SL3 & 8 to 20 stories	N/A	-0.8	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	N/A	-0.8	-0.8	-0.8
FINAL SCORE												

COMMENTS

ATC9/H
30032.01

Detailed Evaluation Required?

YES NO

Figure B3c

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